Research projects Lutz Böhm

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Extract from the CV:

officially (co-)acquired third party funding	(since 2016) approx. 1,7 M€ (unofficially involved approx. +0.3 M€)

SPP1740 "Mass transfer of rising gas bubbles in reacting liquids" (2nd funding period)

The idea of this project is the investigation of the influence of the interaction of bubbles on the mass transfer in reactive bubbly flows. Previously, the experimental work was focused on the determination of the interaction between fluid dynamics, mass transfer and chemical reaction. As in practical applications multiple bubbles interact, here certain bubbles in different types of bubble formations will be investigated. The experimental systems developed in the first funding period will further be used for complementary single bubble experiments. These experiments provide the necessary basic information to evaluate the results of interacting bubble formations. The aim of the complementary single bubble investigations is the determination of mass transfer coefficients. These are determined based on the change of the bubble size during the bubble's contact with the (reacting) liquid phase. The experiments are performed in two apparatuses which were further developed in the first funding period. The apparatuses are a bubble ascent channel and a counter current flow cell. Varied parameters are: The chemical system (WG Klüfers/Schindler/Herres-Pawlis), bubble size, contact time between bubble and liquid, pressure, temperature, educt concentration in the liquid phase. The results will be mathematically modeled with adjusted or new Sherwood correlations while reasonably incorporating all influencing parameters. These correlations will be used to compare systems with more complex velocity and concentration fields in the vicinity of the bubble. These fields will be created under controlled conditions. Several approaches will be tested. A chain of bubbles, an array of bubbles and a bubble swarm which will be stopped with a single bubble following will be investigated. For comparison, turbulence promoters which were developed and investigated in the first funding period by other groups in the priority program will be tested as well (WG Kähler/Schlüter/Thoeming). Besides the investigation of the chemical systems developed in the first funding period, the new and further developed systems with parallel and/or consecutive chemical reactions will be investigated. In some cases, this requires new approaches in the experiments to be able do an accurate quantification. The fully automated experimental apparatuses will be equipped with new stationary and moving spectral measurement techniques (WG Rinke/Simon). This approach has great potential as chemical reactions are developed which have competing chemical reactions resulting in differing discolorations. The chosen approach of following the bubble during its ascent with an optical measurement technique provides results of the rising path, bubble shape and shrinkage behavior under diverse controlled conditions. This information is of high interest for numerically working groups as it can easily be used for validation (WG Bothe/Rzehak/Sommerfeld).

SPP1934 "Interaction of mechanical stresses and productivity of biological agglomerates in (aerated) stirred fermenters" (1st & 2nd funding period)

This project aims at investigating the mechanical stress acting on filamentous microorganisms in stirred fermenters. In the first funding period, the necessary methods to characterize mechanical stress were established. Based on the obtained results and developed methods, the goals set for the 2nd FP focus on three main topics:1. From cultivation broth to model solution and back. In the 1st FP, based on cultivation broths of Aspergillus niger, model systems were developed and used to quantify the particle stress in stirred tanks. The model systems will be further used. In the 2nd FP, to approach better to real cultivation broth while still ensuring good reproducibility, fragmentation experiments will be performed based on diluted broths. This experimental procedure can ensure that a larger number of broths with similar characteristics is produced. Moreover, it allows a controlled design of the properties of the system since the rheology of the broth can be set at a desired level, while the morphology of the bio-agglomerates can be easier characterized in the diluted broth. In the frame of several working packages, cultivations will be performed at the department and in cooperation with other groups of the SPP to broad the data base with results from investigations with other microorganisms, allowing a generalization of the conclusions.2. Fluid dynamic characterization of stirred tanks in diverse configurations. In the 1st FP, during fundamental investigations of conventional and new stirrer types further influencing factors of specific importance for lab and larger scale fermenters were identified. Small changes in the configuration of the stirred system (e.g., baffle position) can influence the fluid dynamics in the tank. Such effects will be investigated with the methods established in the 1st FP. Conventional stirrer types will be optimized and the development of the novel stirrer geometries will be expanded to new radial flow stirrer types. Multiple stirrer configurations will also be part of the study.3. Analysis of the stress history of single bio-agglomerates in the stirred tank. Besides the macroscopic investigation of global properties in the system, the numerical work in the 1st FP showed that local phenomena, as well as the investigation of single particle tracks within the reactor gives a deep insight and significant potential to interpret the impact of particle stress. The characterization of the stress experienced by a particle along its track and its residence time in a region of specific shear rates will be further developed in the 2nd FP. In a joined work with other groups, the results will be compared to different biological systems and apparatuses and further investigated down to molecular level. As outcome of the investigations a base for the choice of stirred tank configurations and stirrer types will be built, to allow a better defined and controlled operation of biotechnological processes in comparison to the current ones.

SFB/TR63 A10 “Gas/liquid mass transfer in reactive multiphase systems” (3rd funding period)

The gas/liquid mass transport is determinant for the investigated reaction of the 3rd phase of SFB/TR 63. The investigation of the mass transport mechanisms is a major challenge due to the occurrence of numerous phase structures and possible transport paths. The goals of project A10 N are the establishment of a fundamental understanding of gas/liquid mass transport for reactive multiphase systems as well as the creation of an accompanying model. To this end the influence of various parameters on the k_La value should be measured using a stirred tank reactor and the contribution of k_L and a differentiated with help of a falling film contactor.

DFG Research Grant “Spatially resolved measurement of transient concentration and temperature fields using Schlieren and LIF technique”

The proposed project deals with the quantitative determination of local and transient concentration and temperature fields near interfaces. Those fields determine the occurring mass or energy transport and will be quantified optically using Schlieren technique. This measurement technique allows a nearly instantaneous, two-dimensional examination of the measurement volume. From the obtained images, the transfer coefficients can be determined non-invasively as well as space- and time-resolved. As a result, it is possible to elucidate transient behavior during mass transfer processes. This behavior has not yet been sufficiently considered for the design of contact apparatuses, which currently depends on integral empirical equations. An example of transient interfacial phenomena is Marangoni convection, which influences the mass transfer at quiescent single droplets. The consideration of these influences opens up great potential for optimizing apparatus design and helps to gain a deeper understanding of the basics of mass transfer processes. In addition, the measurements provide accurate experimental data to validate numerical approaches and improve predictions. As part of the measurements, transport coefficients at different geometries will be determined. At first, energy transport on self-constructed test specimen is measured since the use of temperature fields allow better reproducibility and enable a reliable validation of the measuring procedure. In the context of this validation process, an algorithm for automated analysis of spherical fields is implemented. Based on this, concentration fields near planar surfaces and single droplets are examined. For single droplets, liquid/liquid systems without interfacial instabilities are investigated followed by systems with interfacial instabilities. An important part of the project is the development of the measurement setup with regard to measurement accuracy and reliability. Here, improvements of hardware and software, for example, the integration of a linear guide for a more precise filter positioning or the use of advanced image processing methods are implemented. Due to the first-time use of Schlieren technique for quantitative determination of liquid/liquid mass transport, several validation steps are carried out. Laser Induced Fluorescence (LIF) is used to validate the Schlieren data experimentally. In addition, measurement data will be validated numerically using computational fluid dynamics (CFD) and ray tracing calculations. Additionally, ray tracing calculations offer the possibility to check accuracy as well as sensitivity of the Schlieren measurements. Finally, the construction of a second optical axis enables the validation of assumptions made about the refractive index field. Furthermore, the use of a second optical axis acts as starting point for the analysis of irregularly shaped concentration fields as they occur during interfacial instabilities.